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Care of patients with bacteremia in the setting of a telemedicine-controlled hospital-at-home service is effective and safe

A case-series of 28 patients

Noi Meersohn, MBBS[a,b], Or Dagan, MBBS[a,b], Motro Feingold Iris, MD[b,c], Hila Hakim, RN, MA[d], Gad Segal, MD[b,c,*], Galia Barkai, MD[b,d]

Abstract

Hospital-at-home (HAH) is increasingly recognized as a viable alternative to in-hospital stay across various clinical settings. However, until recently, complex patients, particularly those with bacteremia, were not considered suitable candidates for HAH care. The purpose of this article is to describe a unique series of these high-risk patients and the means for attending them at home, for the first time in scientific literature. A retrospective analysis was conducted on a group of patients with bacteremia who were treated in the setting of a telemedicine-controlled HAH service. Twenty-eight patients with blood stream infections were treated in our HAH service. 60.7% were female, with a patient median age of 77 years. Most patients (64.3%) were admitted from the internal medicine ward; 17.86% (5 patients) were admitted at home, and 17.86% were admitted directly from the emergency department. A significant portion had severe comorbidities: 53.6% presented with malignancies, 21.4% presented with dementia, 42.9% presented with diabetes mellitus, 42.9% had chronic kidney disease, and 7 patients (25%) were on continuous immunosuppressive medication. The mean length of HAH stay was 4.1 ± 2.0 days. The majority (67.9%) were discharged at home, while 28.6% required transfer to in-hospital care. One patient died during the HAH stay, and another died during the 30-day follow-up. Telemedicine-controlled HAH service is a viable alternative to traditional in-hospital care for high-risk patients suffering from bacteremia. This is the first clinical report asserting that careful patient selection and meticulous management during HAH care result in good clinical outcomes.

Abbreviations: BSI = blood stream infection, CAP = community-acquired pneumonia, COVID = corona viral disease 2019, HAH = hospital-at-home, IQR = inter-quartile range, IV = intra venous, MAP = mean arterial pressure, SMC = Sheba Medical Center, UTI = urinary tract infection.

Keywords: bacteremia, blood stream infection, clinical outcome, hospital-at-home, telemedicine

1. Introduction

1.1. Bacteremia and sepsis: common and potentially lethal emergencies

Bacteremia and sepsis pose critical challenges in modern medicine, characterized by their significant impact on morbidity and mortality among hospitalized patients. Despite advancements in medical care, blood stream infections (BSIs) remain a major concern, significantly affecting patient outcomes and straining healthcare systems. The management of BSIs poses a significant challenge in hospitalized patients, particularly when these infections are complicated by comorbidities. For instance, bacteremia frequently occurs in conditions such as pneumococcal community-acquired pneumonia (CAP) and exacerbates patient outcomes. Research indicates that nearly half of pneumococcal CAP patients develop bacteremia, and this subgroup suffers from significantly higher in-hospital mortality rates; 18% compared to 11% in non-bacteremic patients. Furthermore, these patients endure prolonged

NM and OD contributed to this article equally.

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The datasets generated during and/or analyzed during the current study are not publicly available, but are available from the corresponding author on reasonable request.

This study was conducted following an institutional review board approval (#SMC-1266-24), which waived the need for informed consent due to the study's retrospective nature.

All authors gave their approval for this publication.

[a] Faculty of Medicine, St. George's, University of London, Program Delivered by the University of Nicosia at the Chaim Sheba Medical Center, Ramat-Gan, Israel, [b] Education Authority, Chaim Sheba Medical Center, Ramat-Gan, Israel, [c] The Faculty of Health Science and Medicine, Tel-Aviv University, Tel-Aviv, Israel, [d] Sheba Beyond Virtual Hospital, Chaim Sheba Medical Center, Ramat-Gan, Israel.

** Correspondence: Gad Segal, Chaim Sheba Medical Center, Ramat-Gan, Israel (e-mail: gad.segal@sheba.health.gov.il).*

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hospital stays and delayed clinical stability, underscoring the severe impact of bacteremia on the progression of CAP and other comorbidities.[1,2]

In addition to the challenges posed by community-acquired infections, a considerable portion of BSIs originates from nosocomial sources, notably indwelling catheters. Patients requiring such invasive devices often have underlying conditions necessitating prolonged hospital stays and are thus at increased risk for developing bacteremia.[2,3] Mortality rates for patients with BSIs are substantial, ranging from 17% in the general patient population to as high as 38% in those with severe sepsis or septic shock. Individuals with comorbid conditions, such as malignancy or chronic renal failure, face even worse outcomes.[2,4,5] The necessity for hospitalization in such vulnerable populations is often deemed unavoidable but also burdens healthcare systems, highlighting the complexity of managing these cases effectively.[2–6]

1.2. Hospital-at-home: a viable and safe alternative to in-hospital stay

The telemedicine-controlled Hospital-at-home (HAH) service is an innovative healthcare model that delivers hospital-level care to patients in their homes, utilizing telemedicine and remote monitoring technologies. This approach, which gained momentum during the COVID-19 pandemic, provides a viable solution to reduce healthcare costs and alleviate hospital overcrowding while enabling patients to receive care in a familiar environment.[7]

Hospital-at-home has been successfully employed to manage a wide range of medical conditions. Studies have shown that occult myocardial injury or arrhythmia can be safely managed at home through adequate monitoring and timely interventions, with outcomes comparable to traditional hospital care.[7,8] Similar conclusions have been drawn regarding managing electrolyte imbalances such as hypokalemia and hyponatremia, as well as low-risk patients with BSIs and urinary tract infections caused by multidrug-resistant bacteria in the home setting.[7] These findings challenge the traditional view that strict inpatient treatment is necessary, highlighting the potential for HAH to expand its scope safely.

As evidence continues to accumulate, HAH is progressively and systematically shown to be a versatile and reliable alternative to in-hospital care. Recent advancements in telemedicine and remote monitoring technologies have been pivotal in maximizing its effectiveness, allowing for a significant reduction in the burden on hospital resources.[7–13] Recently, Zychlinski et al[14] published the results of a strictly matched, retrospective analysis comparing in-hospital stay and HAH for both COVID-19 and non-COVID patients. Their results showed that the incidence of both re-hospitalizations and mortality was lower with HAH.

1.3. Scarcity of evidence in treating bacteremia in the HAH setting

Despite the growing body of evidence supporting the HAH model for various medical conditions, a significant gap remains in the research regarding its application in treating patients suffering from bacteremia. Particularly in vulnerable populations such as the elderly or those with chronic diseases, bacteremia presents a severe challenge due to its high mortality rates and the complex care required. Traditional management typically necessitates prolonged hospital stays, during which intravenous antibiotics and close monitoring are standard practices. However, the feasibility of managing such cases in an HAH setting has been largely unexplored.

Bacteremia, mainly when originating from healthcare-associated infections, poses a severe risk to patients with underlying comorbidities. Research indicates that modern internal medicine wards are increasingly populated with elderly patients whose risk of infection is heightened by multiple comorbidities, polypharmacy, and the presence of indwelling devices like catheters.[15,16] Managing BSIs in this context requires a specialized, interdisciplinary approach to improve outcomes, especially given the rising prevalence of multidrug-resistant organisms.

Managing bacteremia in an HAH setting is further complicated by the need for careful patient selection and the availability of reliable outpatient support. Studies, such as those by Casado et al, have begun to explore the safety of early oral ambulatory treatment for patients with low-risk bacteremia, demonstrating that, with proper criteria, these patients can be managed outside the hospital with outcomes comparable to traditional in-hospital care.[11] Emerging studies, such as those by Gilboa et al, are extending the current HAH standard of care, enabling diseases and patient populations previously thought to require in-hospital treatment to be safely and effectively managed at home.[7]

The limited data suggest that while HAH could potentially manage bacteremia in selected cases, successful implementation hinges on rigorous protocols and comprehensive telemedicine support. This lack of evidence highlights a critical gap in our understanding, 1 that is crucial to address for expanding the role of HAH in modern healthcare, especially as the demand for alternative care models continues to grow.

2. Methods

This study was conducted following an institutional review board approval (#SMC-1266-24), which waived the need for informed consent due to the study's retrospective nature. Patient data from 2020 to 2024 were extracted from the electronic medical records of the Sheba-Beyond Virtual Hospital, the Telemedicine-based HAH arm of the Chaim Sheba Medical Center, the largest tertiary hospital in Israel. The data were anonymized to protect patient confidentiality.

Our sample size was derived from the available patients hospitalized during our first 4 years of activity. Since no previous similar reports are available in the literature, we decided to analyze this group of patients. We identified 28 patients hospitalized at their homes due to positive blood cultures obtained at the emergency department, during an initial stay in an internal medicine department, or at their homes. Patients were admitted to the HAH from their home, the emergency department, or the internal medicine ward if they met the following criteria: they were hemodynamically stable mean arterial pressure (MAP >70 mmHg and without tachycardia [heart rate over 100/min] at rest), did not require additional imaging (either ultrasound of computed tomography), required antibiotics no more than twice daily (aligned with the service's provision of up to 2 home visits per day), and had a supportive environment with a caregiver present throughout their home hospitalization (either a family member or a nursing caregiver that lives with the patient at his/her home). Patients were excluded if they were under 18 years of age or did not have a diagnosis of bacteremia or a positive blood culture upon admission to Sheba Beyond. Before approval for home hospitalization, all eligible patients were evaluated by an experienced internal medicine physician.

Patients in the HAH program received daily telemedicine consultations with an internist via video calls (in a designated telemedicine platform by Datos-Health [333 West 52nd St. Suite; 1208. New York, NY 10019] and a remote stethoscope telemedicine platform by TytoCare™ [https://www.tytocare.com]) and at least 1 in-person visit per day from a trained nurse for vital sign measurements and medication administration.

Additionally, nurses initiated 2 daily telephone calls for follow-up and self-reporting of vital signs. Blood and urine tests were conducted at the physician's discretion, including creatinine, electrolytes, complete blood count with differential, cultures, and relevant drug levels. Antibiotics were administered during the nurse's visit. A call center was available for patients and their families to address questions and report new symptoms.

A comprehensive retrospective manual review of medical records was conducted to exclude false-positive culture results and irrelevant cases, such as patients hospitalized for less than 1 day. Our analysis includes a detailed description of patients' demographics, baseline morbidities and medications, types of bacteria, antibiotics administered, and clinical outcomes during hospitalization and at 30- and 90- days post-HAH discharge.

Data analysis involved assessing continuous variables for normal distribution using Q–Q plots. Normally distributed data were reported as means and standard deviations, while non-normally distributed data were presented as medians and inter-quartile ranges (IQR). Categorical data were described using absolute numbers and percentages.

3. Results

3.1. Patients' demographics

Between 2020 and 2024, 62 patients with positive blood cultures indicating bacterial infections were treated at Sheba Medical Center's HAH platform Sheba Beyond. Of these, 29 were diagnosed with true BSIs, with 1 patient excluded for not meeting the inclusion criteria as outlined in the methods section. The characteristics of the remaining 28 patients are detailed in Table 1. The median age was 77 years (IQR: 64 to 87), with a majority being female (17, 60.71%). Most patients were admitted from the internal medicine ward (18, 64.29%), while 17.86% (5 patients) were admitted from home, and 17.86% (5 patients) were admitted directly from the emergency department. The medical history of the patients revealed significant comorbidities, including: 53.57% (15 patients) with active malignancies, 21.43% (6 patients) with dementia, 42.86% (12 patients) with diabetes mellitus, and 42.86% (12 patients) with chronic kidney disease. Additionally, 25% (7 patients) were on immunosuppressive medications for various clinical indications.

3.2. Patients' clinical outcomes

The mean length of their HAH stay (LOS) was 4.14 ± 2.01 days. A majority (19, 67.86%) were discharged at their homes, while 8 (28.57%) required transfer to in-hospital medical care. All patients referred back to hospital care were considered as non-adequately responding to antibiotic therapy and as such, necessitated repeat or more thorough imaging studies or eligible for antibiotic "window"–stopping antibiotics and resampling blood cultures – a process deemed inappropriate in the HAH settings. Unfortunately, 1 patient (3.57%) died during the HAH stay, and another 1 died during the 30-day follow-up. Additionally, 6.90%[2] were readmitted to HAH for continued IV care and monitoring within 30 days (see Table 1 for further information on clinical outcomes).

Although formal patient satisfaction surveys were not conducted, anecdotal evidence suggests high satisfaction levels, with patients and their families frequently expressing appreciation and providing positive feedback to the staff.

Table 1

Patients' demographics and clinical characteristics and their HAH clinical outcomes.

	Demographic			Medical background					HAH clinical outcomes		
Patient #	Gender	Age	Admitted from (HM/ER/HS)	Malignancy (yes/no)	Dementia (yes/no)	DM (yes/no)	CKD (yes/no)	Immune suppression (yes/no)	Tranfer to hospital	Death during HAH	LOS (d)
1	F	66	HS	Yes	No	No	No	Yes	0	No	4
2	F	93	HM	No	Yes	No	Yes	No	0	No	4
3	M	77	HS	No	No	Yes	Yes	No	1	No	4
4	F	77	HM	No	Yes	Yes	Yes	No	0	No	3
5	F	87	HM	Yes	No	No	No	Yes	0	No	9
6	F	92	HM	Yes	No	No	No	No	0	No	5
7	F	87	HS	Yes	Yes	No	No	No	1	No	3
8	F	74	HS	Yes	No	Yes	Yes	Yes	0	No	8
9	M	70	ER	No	No	Yes	No	No	0	No	4
10	M	74	HS	Yes	No	No	Yes	No	0	No	4
11	F	62	HS	Yes	No	Yes	Yes	Yes	1	No	8
12	M	23	ER	No	No	No	No	No	0	No	5
13	M	63	HS	Yes	No	No	No	Yes	0	No	3
14	F	64	ER	No	No	No	No	No	1	No	2
15	F	90	HS	Yes	No	Yes	No	No	1	No	5
16	F	90	HS	Yes	No	Yes	No	No	0	No	2
17	F	85	HM	No	No	No	No	No	1	No	1
18	M	82	HS	No	No	No	Yes	No	0	No	5
19	F	60	HS	Yes	No	No	Yes	No	1	No	5
20	F	76	ER	No	No	No	No	No	0	No	3
21	M	83	HS	No	Yes	Yes	Yes	No	NA	Yes	1
22	F	91	ER	Yes	No	Yes	No	No	1	No	1
23	F	77	HS	Yes	Yes	Yes	Yes	No	0	No	3
24	M	83	HS	No	Yes	Yes	No	No	0	No	5
25	M	87	HS	Yes	No	No	Yes	Yes	0	No	5
26	M	51	HS	Yes	No	No	No	No	0	No	3
27	M	64	HS	No	No	No	No	No	0	No	5
28	F	61	HS	No	No	Yes	Yes	Yes	0	No	6

ER = emergency room, HAH = hospital-at-home, HM = home, HS = hospital.

Table 2

Microbiology and antimicrobial therapy characteristics during patients' HAH stay.

Patient #	Bacteria characteristics	Antibiotics pre-HAH	Antibiotics during HAH		Antibiotics recommended at discharge/ hospital transfer
	Blood culture result		Antiobiotic	Duration (d)	Antibiotic
1	*Klebsiella pneumoniae*	Yes	Ertapenem	9	0
2	Proteus Mirabilis	No	Ceftriaxone	4	Cefuroxime Axetile
3	Salmonella Species	Yes	Ceftriaxone	4	Ceftriaxone
			Levofloxacin	4	Levofloxacin
4	*Streptococcus agalactiae*	No	Ceftriaxone	1	Levofloxacin
			Ceftriaxone + Ampicillin	1	
			Levofloxacin	1	
5	*Escherichia coli*	No	Ofloxacin	10	Ofloxacin
			Ceftriaxone	3	
6	*Escherichia coli*	No	ciprofloxacin	2	ciprofloxacin
7	Acinetobacter Species	No	Amikacin	3	Ceftriaxone
			Amoxicillin + Clavulanic acid	2	Amikacin
8	*Escherichia coli*	No	Ertapenem	8	0
9	*Klebsiella aerogenes*	No	Ceftriaxone	4	Ciprofloxacin
			Ciprofloxacin	1	
10	*Escherichia coli*	No	Ceftriaxone	3	Ofloxacin
			Ofloxacin	2	
11	*Escherichia coli*	No	Ceftriaxone	9	0
			Resprim	9	
12	Salmonella Species	Yes	Ceftriaxone	3	Ciprofloxacin
			ciprofloxacin	2	
			Azithromycin	4	
13	*Klebsiella pneumoniae*	Yes	Ertapenem	3	0
			Trimethoprim + Sulphamethoxazole	3	
14	*Streptococcus pyogenes*	Yes	Amikacin	2	Ceftriaxone
			Vancomycin	1	
15	*Morganella morganii*	Yes	Ertapenem	10	Ertapenem
16	*Morganella morganii*	Yes	Ertapenem	2	0
17	*Haemophilus influenzae*	Yes	Ceftriaxone	1	Ceftriaxone
			Levofloxacin	1	Levofloxacin
18	*Staphylococcus haemolyticus*	No	Ceftriaxone	5	0
19	*Klebsiella pneumoniae*	No	Ertapenem	4	0
			Trimethoprim + Sulphamethoxazole	5	
20	*Klebsiella pneumoniae*	Yes	Ceftriaxone	3	Ciprofloxacin
			ciprofloxacin	1	
			Amikacin	3	
21	*Escherichia coli*	No	Ertapenem	1	0
22	Bacteroides Fragilis Group	No	Ceftriaxone	1	Ceftriaxone
					Metronidazole
23	*Escherichia coli*	No	Ceftriaxone	3	Ofloxacin
24	*Escherichia coli*	Yes	Ceftriaxone	4	0
25	*Escherichia coli*	Yes	Ertapenem	5	Ceftriaxone
					Ertapenem
					Meropenem
					Vancomycin
26	Priestia Flexa	Yes	Ceftriaxone	2	Ofloxacin
			Ofloxacin	3	
27	*Escherichia coli*	Yes	Ceftriaxone	4	Ofloxacin
			Ofloxacin	2	
28	*Klebsiella pneumoniae*	Yes	Ertapenem	7	0
			Trimethoprim + Sulphamethoxazole	6	

HAH = hospital-at-home.

3.3. Microbiological characteristics

Table 2 describes the genera of bacterial growth from blood cultures and the antibiotics used based on sensitivities. *Escherichia coli* was the most common bacterium, found in 10 (35.7%) of patients, followed by *Klebsiella pneumoniae* in 5 (17.9%). Various other bacterial pathogens were identified in the remaining cases. Additionally, 17 (60.7%) patients had positive urine cultures during their HAH stay or in the preceding in-hospital stay.

All antibiotic regimens and agents' selection were based on our medical center policies, both for empiric antibiotics and for targeted therapies. Nevertheless, as it is custom within the Sheba Medical Center departments, senior physicians have the ability to change and escalate the antibiotic regimens – this did not differ in the HAH settings. The most commonly administered antibiotics during HAH were ceftriaxone, used in 16 (57.1%) patients, with an average treatment duration of 3.4 ± 1.9 days, and ertapenem, used in 9 (32.1%) patients, with an average duration of 5.4 ± 3.2 days. Other antibiotics administered included levofloxacin, ofloxacin, and trimethoprim-sulfamethoxazole, among others. All antibiotics were initially administered on an empirical basis, later to be replaced, as needed, with alternative regimens when the full sensitivity profile of the bacteria was presented by the microbiology lab.

4. Discussion

This study is among the first to demonstrate that bacteremia, a condition traditionally managed in an in-hospital setting, can be safely and effectively treated from the outset in an HAH environment. Our cohort consisted of 28 patients diagnosed with bloodstream infections that would typically necessitate in-hospital admission based on current standards of care. However, by leveraging a telemedicine-controlled framework – including daily remote consultations with a senior experienced physician, along with multiple in-person visits by nurses and other medical personnel (e.g., imaging technicians, medical students, etc) as needed, we were able to deliver safe and effective care in the home setting. Additionally, we regularly consulted a specialist in infectious diseases as part of the care plan, ensuring comprehensive oversight in managing these complex cases.

The ability to manage bacteremia at home represents a significant advancement in the use of HAH services. While the literature supports the efficacy, safety, and practicality of the HAH models, conditions such as bacteremia have traditionally been considered too severe to manage outside of a hospital due to the need for intravenous antibiotic therapy and intensive monitoring.[7,14–21] Our findings challenge this paradigm, showing that HAH service, either alone or in a hybrid model with an initial in-hospital stay, can provide a viable alternative to traditional full inpatient care with appropriate patient selection and continuous telemedicine support.

67.9% of patients were successfully treated at home, while only 28.6% required transfer to in-hospital care. This transfer rate aligns with findings from other studies evaluating similar home hospitalization models, emphasizing the importance of rigorous patient selection and monitoring to ensure patient safety.[22,23] The mortality rate in our study was 3.6% during HAH hospitalization and 7.1% in our 90-day follow-up, which is markedly lower than the mortality rates reported in-hospital settings for similar high-risk populations.[2,24] Consistent with existing literature, we also note that only 2 patients (6.9%) required readmission to HAH for continued IV care within the 90-day follow-up.[21,22] Importantly, these readmissions were managed within the HAH system, avoiding the need for traditional in-hospital readmission. This reflects the flexibility of this HAH model and its ability to provide ongoing, high-quality care even when complications arise.

The mean LOS in the HAH setting for our cohort was 4.1 ± 2.0 days, which aligns with the average duration of intravenous antibiotic administration for bacteremia (LOS varies with severity and patient comorbidities).[25,26] This suggests that the HAH model can deliver a comparable and perhaps more customizable level of care to that provided in hospitals.

5. Limitations

While our results are promising, they must be interpreted in light of the study's limitations. The relatively small sample size and retrospective point-of-view may limit the generalizability of our findings. Nevertheless, as stated earlier, this is the first clinical report in the literature of HAH patients suffering from bacteremia. Additionally, the study did not include a formal patient satisfaction survey, relying instead on anecdotal evidence, which may not fully capture the patient and family experience. Future research should aim to validate these results in larger, prospective studies, potentially exploring the long-term outcomes of HAH care for bacteremic patients. Such research, in a prospective design, would avoid potential selection bias in the current form of retrospective analysis, and should also include an analysis of the financial impact of this model on the healthcare system.

6. Conclusions

Our study provides compelling evidence that treating carefully selected patients suffering from bacteremia in a telemedicine controlled HAH setting is feasible and effective. By challenging conventional healthcare paradigms, this research supports a shift towards patient-centered, home-based care, potentially reducing the burden on hospitals and improving patient outcomes. These findings encourage the adoption of HAH services as a standard care option for bacteremia and other serious infections, as long as the patients are within strict inclusion criteria, potentially transforming the management of such conditions in the near future.

Author contributions

Conceptualization: Noi Meersohn, Or Dagan, Hila Hakim, Gad Segal, Galia Barkai.
Data curation: Noi Meersohn, Or Dagan, Hila Hakim, Gad Segal.
Formal analysis: Noi Meersohn, Or Dagan, Hila Hakim, Gad Segal.
Investigation: Hila Hakim, Gad Segal, Galia Barkai.
Methodology: Noi Meersohn, Or Dagan, Gad Segal, Galia Barkai.
Project administration: Or Dagan, Gad Segal, Galia Barkai.
Supervision: Gad Segal, Galia Barkai.
Validation: Noi Meersohn, Or Dagan, Hila Hakim, Gad Segal, Galia Barkai.
Visualization: Hila Hakim, Gad Segal.
Writing – original draft: Noi Meersohn, Or Dagan, Hila Hakim, Gad Segal.
Writing – review & editing: Noi Meersohn, Or Dagan, Hila Hakim, Gad Segal.

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